

88. The method according to claim 87, further comprising:

detecting a direction of movement of the endangered object in the warning zone; and  
only generating the warning if the endangered object is moving towards the protection zone.

89. The method according to claim 86, wherein the work element is disabled

based on the presence of an endangered object within the detection region only if the  
endangered object is in the protection zone.--

### REMARKS

Claims 43-89 are now pending in this application. Claims 1-42 have been cancelled by this Amendment. Each of the pending claims is believed to define an invention which is novel and unobvious. Favorable consideration of this case is respectfully requested.

This application was originally filed on January 8, 2001 with a German language specification. A literal translation of the German specification is being submitted with a Response to the Notice of Missing Parts. A statement by the translator stating that the translation is accurate is attached to the literal translation.

A substitute specification is also submitted herewith. A marked up copy showing the changes made to the literal translation and a clean copy of the substitute specification are being provided to the office in accordance with 37 C.F.R. 1.125(b). No new matter has been included in the substitute specification. It is hereby requested that the substitute specification be used for examination purposes in the office.

Also submitted herewith is a substitute drawing sheet for Figure 2 and a new drawing sheet including Figure 2A. These figures illustrate elements recited in the claims originally

filed, but not included in the drawings, for example, the illumination system, the evaluation unit, and the warning indicator are not illustrated in block form. As these elements are recited in the claims originally filed, no new matters is being entered in the drawings.

Accordingly, favorable consideration of this case and early issuance of a Notice of Allowance are respectfully requested.

In the event that any further cooperation in this case is deemed to be necessary to complete its prosecution, the Examiner is respectfully urged to contact the undersigned at the telephone number listed below.

Please charge any fee deficiency or credit any overpayment to Deposit Account No. 22-0261.

An early examination is respectfully solicited.

Respectfully submitted,

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# APPARATUS AND METHOD FOR MONITORING A DETECTION REGION OF A WORKING ELEMENT

## Field of the Invention

5           The invention relates to an apparatus and a method for monitoring a detection region of a working element.

## Background of the Invention

          The working element can be formed by, for example, a  
10   folding press that has at least one upper tool and one lower tool, which cooperate to bend and bevel workpieces comprising pieces of sheet metal, in particular. For this purpose, the upper tool is guided toward the lower tool in a pressing movement, thereby deforming a piece of sheet  
15   metal, which is disposed between the two tools, along a fold line. Folding presses of this type are potentially hazardous to the operator, because the workpiece must usually be guided manually during the pressing movement. Consequently, the operator's hands and fingers are near the  
20   upper and lower tools, or near the squeezing and shearing points of the folding press or the workpiece, which puts him the operator at risk for serious injury.

To make these detection regions safer, it is standard practice to use protective devices that disable the working element if the operator has inadvertently intruded into the detector region.

5        These protective devices can take the form of two-handed switches that protect the operator's hands by requiring the actuation of two levers to initiate and maintain a potentially dangerous movement in a folding press. The operator must therefore keep both hands on the  
10 levers, which safeguards him against injury during press operation.

A drawback of this device, however, is that other persons in the detection region are unprotected. A further drawback is that the operator cannot manually guide the  
15 workpiece during machining, which ~~is perceived as~~ can be problematic. The operator therefore often chooses to disable the protective device and guide the workpiece manually in the detection region, without protection.

Safety light curtains are also used as protective  
20 devices. DE 39 39 191 C3, for example, discloses such a device. In this case, the safety light curtains comprise numerous pairs of transmitters and receivers that respectively form a light barrier.

The light beams emitted by the transmitters and aimed at the respectively associated receivers cover a planar, two-dimensional monitoring region. It is possible to detect that a hand is approaching a detection region, whereupon the working element is disabled.

A safety light curtain of this nature is typically disposed vertically, and serves to bar access to a folding press. In the machining of larger pieces, it is advantageous to arrange the safety light curtain horizontally to secure the region. A disadvantage of this arrangement is that a plurality of safety light curtains is required for completely securing the detection region of this folding press, especially with respect to preventing access and securing the region. This requirement not only raises costs to an undesirable level, but is also associated with complicated assembly, often with only insufficient space available for the devices.

DE 196 19 688 A1 relates to a method for video monitoring of operator areas, such as of a press, in which a video camera optically detects the operator area to be monitored, and generates an electronically-processable image of the open operator space, which the camera supplies to an image processor, where it is stored.

Prior to each startup of the press, the video camera records an image of the operator area and compares the generated image to the image stored in the image processor. The press can only be started up if the new image is  
5 identical to the stored image.

A disadvantage of this method is that any deviation of a current image from the reference image disables the press, even if the deviation would not pose a threat to the respective operator. This system ~~possesses~~ results in a  
10 low availability of the press, which unnecessarily limits the operating times of the press.

#### Summary of the Invention

It is the object of the invention to create a system  
15 that assures reliable monitoring of a detection region of a working element without unnecessarily limiting its availability.

~~—The object is accomplished by the features of claims 1 and 26. The dependent claims disclose advantageous~~  
20 ~~embodiments and modifications of the invention.~~

In accordance with the invention, for monitoring a detection region of a working element, at least one camera continuously ~~detects~~ monitors the detection region.

The image information generated in the camera during the ~~detection~~ monitoring is read into an evaluation unit.

This image information is used in a comparison to reference images that are stored in the evaluation unit, and/or in a color-feature analysis, to detect endangered objects within at least one protection zone in the detection region.

If at least one endangered object is detected within the protection zone, the evaluation unit disables the working element, whereas the evaluation unit enables the working element if there is no endangered object in the protection zone.

A significant advantage of the protective device of the invention is that a three-dimensional detection region of the working element can be ~~detected~~ monitored. One camera can perform multiple monitoring functions. Notably, a suitable selection of the monitoring region ~~detected by~~ of the a camera assures both access prevention and the securing of the region of the working element.

A further advantage is that endangered objects located within the detection region detected by a camera, such as a person's hands or fingers, can be distinguished from non-endangered objects. The color-feature analysis of the

invention ~~figures into~~ may be used for this distinction.

Also, the reference images can be selected such that they detect the non-endangered objects located in a protection zone. Then a comparison of the current image information  
5 to the reference images can be used to separate and detect the endangered objects.

In principle, the image information can be compared to the reference images, or evaluated in a color-feature analysis, for assessing whether an endangered object is  
10 located in the protection zone.

The two methods are advantageously evaluated in a combination. This can significantly increase the verification reliability of the apparatus according to the invention.

15 For example, the working element can only be enabled if the two methods do not indicate the presence of an endangered object in the protection zone. Therefore, the danger of non-detection of an endangered object can be greatly reduced.

20 The protective device according to the invention only disables the working element if an endangered object enters a protection zone inside the detection region.



In the simplest case, the protection zone extends over the entire detection region detected by the camera. The protection zone is advantageously dimensioned as a defined partial section of the detection region through the input  
5 of parameters into the evaluation unit, or through a learning process. The protection zone can thus be precisely tailored to the danger points to be detected. This avoids monitoring of areas that are not of concern in terms of safety, which considerably increases the  
10 availability of the protective device of the invention without reducing the level of safety in the monitoring.

In an advantageous embodiment of the invention, the protection zone can be allocated at least one warning zone, which preferably adjoins the protection zone directly. If  
15 an endangered object enters the warning zone, a warning signal is emitted, which provides an early warning for the operator or other person of the impending entry of an endangered object into the protection zone. The operator can therefore undertake appropriate measures to prevent the  
20 endangered object from entering the protection zone, thereby avoiding the disabling of the working element. This prevents unnecessary downtime of the working element.

In an advantageous modification of the invention, numerous protection zones and warning zones can be provided within a detection region, corresponding to the requirements of the respective application, in which  
5 instance the working element is only disabled if an endangered object is detected in at least one protection zone. Accordingly, a warning signal is emitted if an endangered object is detected in at least one warning zone.

10 Brief Description of the Drawings

The invention is described below in conjunction with the following drawings: ~~Shown are in:~~

Figure 1: a front view of a working element formed by a folding press, with two cameras being disposed in  
15 front of the element for monitoring detection regions;

Figure 2: a side view of the arrangement according to Figure 1;

Figure 2a: a block diagram of the arrangement according to  
20 Figures 1, 2;

Figure 3: a cross-section through a section of the arrangement according to Figure 1, with a

protection zone and a warning zone being disposed  
inside a detection region;

Figure 4: a working element embodied as a printing press,  
having a camera for monitoring a monitoring  
5 region that extends over the region of the feed  
and output mechanisms of the press;

Figure 5: the printing press according to Figure 4, having  
two cameras for monitoring the region of the  
output mechanism and the feed mechanism;

10 Figure 6: a region monitored by a camera, namely the paper  
feed at the feed mechanism of the printing press  
according to Figure 4 or 5; and

Figure 7: a working element embodied as a welding robot,  
having a camera for monitoring a detection region  
15 in the region of access to the welding robot.

#### Detailed Description of the Invention

Figures 1 through 3 illustrate an exemplary embodiment  
of a working element 100 configured as a folding press 1,  
20 which is monitored with the apparatus of the invention for  
the purpose of avoiding putting an operator at risk.

The folding press 1 serves to bend and shape  
workpieces 2, particularly pieces of sheet metal. An upper

tool 3 and a lower tool 4, which cooperates with the upper tool, shape a workpiece 2. During a pressing movement, the upper tool 3 and lower tool 4 are guided toward one another, so a workpiece 2 located between them is beveled  
5 or bent along a fold line.

In the present embodiment, the folding press 1 has four adjacent pairs of upper tools 3 and lower tools 4. For machining the workpieces, an operator usually brings the workpieces 2 into predetermined positions between the  
10 upper tool 3 and the lower tool 4. In the process, the operator is particularly at risk of serious injury when he puts his hands or fingers into the region between the upper tool 3 and the lower tool 4. The movement of the workpiece 2 during the pressing process also poses a tremendous risk  
15 of injury for the operator.

The apparatus according to the invention, which constitutes a contactless protective device, is provided for protecting the operator.

The apparatus includes at least one camera 5,  
20 preferably a video camera. This camera 5 detects a detection region 6 of the working element 100, corresponding to the aperture angle of the optics, not shown, of the camera 5. In the present embodiment, two

cameras 5 are provided in front of the folding press 1~~7~~.  
Each camera 5 detects a detection region 6, in which two  
pairs of upper tools 3 and lower tools 4 are located.

As can be seen from Figures 1 through 3, the detection  
5 region 6 monitored by a camera 5 forms a three-dimensional  
spatial area whose base outline has a rectangular cross  
section. The long side of the detection region 6 extends  
along the fold lines of the upper tools 3 and lower tools 4  
located in the detection region 6. The cross-sectional  
10 surface of the detection region 6 tapers upward toward the  
camera 5, corresponding to the aperture angle of the optics  
of the camera 5.

The camera 5 is integrated into a housing that is  
seated in a form-fit on a mechanical holding device 51, ~~not~~  
15 ~~shown~~, such that the holding device is disposed at an  
incline above the upper tools 3 and lower tools 4. The  
mechanical holding device 51 can be adjusted in all three  
spatial directions for orienting the camera 5 relative to  
the upper tools 3 and lower tools 4. The adjustment is  
20 performed independently of the camera 5, so the adjustment  
of the holding device is even maintained when the camera 5  
is ~~exchanged~~ replaced.

A separate illumination system 52, ~~not shown~~, can be associated with each camera 5 for achieving uniform illumination of the respective detection region 6.

An evaluation unit 53, ~~also not shown~~, is provided in  
5 the housing of the camera 5 for evaluating the image information obtained by the camera 5. The evaluation unit 53 is formed by a microprocessor or the like.

In the evaluation unit 53, the image information is assessed so as to permit the detection of endangered  
10 objects. In particular, endangered objects 54 and non-endangered objects 55 are distinguished. Endangered objects include the operator, more precisely his hands or fingers. Non-endangered objects include, for example, the front walls of the folding press 1 or other static objects  
15 in the surrounding area of the folding press 1, especially the workpieces 2 to be machined.

In accordance with the invention, in the evaluation unit 53, an assessment is performed to determine whether an endangered object 54 is located in a protection zone 7  
20 inside the detection region 6. If this is the case, the evaluation unit disables the working 100 element to protect the operator. If, in contrast, there is no endangered 54

object in the protection zone 7, the evaluation unit 53 enables the operation of the working element 100.

To this end, a binary switching signal is transmitted to the control 57 of the working element 100 via a  
5 switching output 56 connected to the evaluation unit 53.

In the evaluation unit 53, the evaluation is performed as follows: Depending on whether an endangered object 54 is present in the protection zone 7, the binary switching signal has a specific switching state. The respective  
10 switching state is transmitted to the control 57 of the working element 100, whereupon the working element is enabled or disabled. The switching output 56 is advantageously connected to the control 57 of the working element 100 via a bus system.

15 To assure the necessary safety level in the respective monitoring process, the evaluation unit 53 with the associated hardware has, in part, a redundant design  
~~partially has redundant hardware.~~ The software for the evaluation unit also has a safety standard that corresponds  
20 to the safety level. Finally, the bus system is also advantageously embodied as a safety bus system 58.

In the simplest case, the protection zone 7 can be congruent with the monitoring region detected by the camera 5.

The protection zone 7 is advantageously limited to the 5 regions inside the detection region 6, in which the operator is at risk. In the scenario illustrated in Figure 3, the protection zone 7 represents a three-dimensional partial region of the detection region 6, with the long-side border extending parallel to the fold lines of the 10 upper tools 3 and the lower tools 4 in the detection region 6, the tools being located within the protection zone 7. Thus, the dangerous region at the upper tools 3 and lower tools 4 is detected directly with the protection zone 7.

The embodiment illustrated in Figure 3 has a warning 15 zone 8 in addition to the protection zone 7. The warning zone 8 is disposed in front of the upper tools 3 and lower tools 4, and directly adjoins the protection zone 7. The protection zone 7 and the warning zone 8 have approximately the same dimensions, notably about the same cross-sectional 20 surfaces.

A warning output 59, which controls a warning indicator 60, ~~not shown~~, is associated with the warning zone 8 via the evaluation unit 53. In the evaluation unit



53, it is determined whether an endangered object 54 is located in the warning zone 8. Depending on the outcome, a binary signal is generated, with the respective switching state of the signal being transmitted via the warning

5 output 59. If an endangered object 54 is registered in the warning zone 8, the warning indicator 60 is activated by the generated switching state, so the warning indicator emits an acoustical and/or optical warning signal.

This signals to the operator that an endangered object  
10 54 is located in the warning zone 8, and thus in the immediate vicinity of the protection zone 7. In particular, the operator is informed that his fingers or hands are in the vicinity of the protection zone 7, so the operator can eliminate the threat of injury by removing his  
15 hands from the warning zone 8 without entering the protection zone 7, which would lead to an undesired disabling of the folding press 1.

In an advantageous modification of the invention, the direction of movement of an endangered object within the  
20 warning zone 8 is detected. In this case, the warning indicator 60 is only activated if an endangered object 54 inside the warning zone 8 is approaching the protection zone 7.

In principle, a detection region 6 detected by a camera 5 can be divided into a plurality of protection zones 7 and warning zones 8. Here, a separate switching output 56 is associated with a protection zone 7, and a  
5 separate warning output 59 is associated with each warning zone 8.

The evaluation unit 53 disables the working element 100 if at least one endangered object 54 is registered in at least one protection zone 7.

10 Depending on the application, a separate warning indicator 60 can be provided for each warning zone 8. As an alternative, a plurality of warning outputs 59 can be associated with one warning indicator 60.

The ~~switching~~ states of the switching outputs 56 and  
15 the warning outputs 59 can be visually indicated in a suitable way, which requires appropriate display elements 61.

In the embodiment according to Figure 3, the visual display can be effected, for example, in the manner of a  
20 traffic light. If such a light displays a red light, this means that an endangered object 54 is located in the protection zone 7. A yellow signal corresponds to the presence of an endangered object in the warning zone 8,

with an empty protection zone 7. A green signal indicates that there is no endangered object 54 in either the protection zone 7 or the warning zone 8.

The protection zone 7 and/or the warning zone 8 can be dimensioned, for example, through the input of parameters into the evaluation unit 53.

The evaluation unit 53 can, for example, be connected to a computer, such as a PC, for starting up and configuring the protective device. The mouse of the PC can be used to graphically input the parameters for the protection zone 7 and/or warning zones 8.

As an alternative, the protection zones 7 and/or warning zones 8 can be dimensioned through a learning process prior to the startup of the protective device.

Furthermore, regions inside the detection region 6 that ~~are~~ are extracted in alternately activated and deactivated during the monitoring process can also be defined in the described configuration options. These regions can overlap the protection zones 7. In the following operating phase of the protective device, these regions are preferably activated at preset times. During these times, if an endangered object enters such a region, ~~this does not lead to the disabling of the working element~~

100 is not disabled or the emission of a warning signal is not emitted.

The definition of these regions is especially practical if, for example, dangerous tools of a working  
5 element 100 are disabled at preset intervals, so the operator is not at risk in these regions during these time intervals.

The definition of the protection zones 7 and the warning zones 8 during the configuration is application-  
10 specific, and is adapted to the respective shape of the workpieces 2 to be machined with the working element 100.

In the embodiment according to Figures 1 through 3, pieces of sheet metal are bent. Their geometries can be read as CAD data files into the evaluation unit 53, so  
15 suitable protection zones 7 and/or warning zones 8 can be defined accordingly.

The regions in which the operator is allowed to hold the bending part for machining are advantageously also read  
in with the CAD data files. The protection zones 7 and  
20 warning zones 8 can have a correspondingly-adapted embodiment.

In a particularly advantageous ~~feature~~ embodiment, visible optical light beams 62 indicate the borders of the

respective protection zones 7 to the operator. For the beams, the apparatus of the invention includes a transmitter, which is actuated by the evaluation unit 53 and emits light beams in the visible range. The optical  
5 light beams provide a visual indication of straight-line borders of the protection zones 7.

Finally, in the configuration of the protection device of the invention, the device can learn about endangered objects and/or non-endangered objects during a learning  
10 process.

In the apparatus of the invention, a camera 5 continuously ~~detects~~ monitors a detection region 6, with the image information that has been generated in the camera 5 being read into the evaluation unit 53.

15 According to a first variation of the method of the invention, a color-feature analysis serves in the evaluation of the image information.

The image information of the camera 5 is then read, as color values, into the evaluation unit. The color-feature  
20 analysis aids in the distinction between endangered objects and non-endangered objects 53.

Each image of the camera 5 is formed by a pixel matrix, with specific color values of the base colors of red, green and blue being associated with each pixel.

A threshold-value unit, which is a component of a ~~neuronal~~ neural network, assesses these images. In principle, the color values of the different base colors can be assessed with separate threshold values that are generated in the threshold-value unit.

In the present embodiment, in the evaluation unit 53, a linear combination of the individual color values of the base colors is formed for each pixel of an image. ~~The~~ individual color values are weighted with weighting factors that are stored in the evaluation unit 53 or can be predetermined by the unit. This linear combination is assessed with a threshold value that has been generated in the threshold-value unit. In this way, a binary image is created from the color image generated in the camera 5. The threshold value and the weighting factors are adapted such that the endangered objects are, for example, bright regions of foreground pixels that stand out against a dark background of background pixels.

The threshold values and the weighting factors are advantageously determined during the learning process. At

this time, the colors of the endangered objects are learned. The endangered objects are preferably the hands and/or fingers of the individual operating the working element 100.

5        In principle, the hands and/or fingers of numerous persons can also be learned.

As an alternative for the case of endangered objects comprising body parts, it is required that the persons wear a protective covering of a predetermined color. In this  
10 way, the parameters for the image evaluations are adapted to the color of the protective covering.

In the binary images generated by the threshold-value unit, the endangered objects form connected regions of foreground pixels that stand out against the background  
15 pixels. Non-endangered objects such as the workpieces 2 and the working element 100 form the background pixels.

At isolated points, the binary image can be noisy due to pixel errors, so individual foreground pixels appear in the background region. These pixel errors can be  
20 eliminated through the application of morphological operators. In the process, isolated regions of foreground pixels whose surface areas are smaller than a predetermined minimum surface area are eliminated. These minimum surface

areas are selected to be significantly smaller than the surface area of the smallest endangered object to be detected.

In accordance with a second variation of the method of the invention, the images that have been generated by the camera 5 and read into the evaluation unit 53 are compared to reference images stored in the evaluation unit 53 for recognizing endangered objects within the protection zones 7 and/or the warning zones 8.

In an advantageous embodiment of the invention, the images and reference images are converted into binary edge images prior to the comparison. For this purpose, the amounts of the gradients of the brightness distributions of an image or reference image are evaluated, preferably with a suitable threshold value. The binary edge images formed in this manner contain structures of lines on a homogeneous background, with the lines corresponding to the edges of the objects located in the detection region 6.

This evaluation renders the detection of objects extensively independent of the respective illumination conditions, so fluctuations in brightness, such as changing sunlight-radiation, do not result in erroneous detections.



To further increase the verification reliability, the protection zone 7 is advantageously bordered at least partly by a reference object having a defined contrast pattern. The reference object can be formed by, for  
5 example, a disk that has a characteristic surface pattern, and is mounted to the folding press 1 beneath a lower tool 4 such that it is positioned in the viewing field of the camera 5. The surface pattern of the disk can be embodied, for example, as a colored striped pattern, so it is clearly  
10 distinguished from the color patterns of the endangered objects.

The comparison of the current images to the reference image containing the reference object allows the endangered objects in the protection zone 7 to be detected with a high  
15 reliability.

This method ~~does~~should not include a feature analysis of the objects entering the protection zone 7, so every such object is regarded as an endangered object 54.

In the machining of workpieces 2 by the working  
20 element 100, the workpieces 2 can enter the protection zone 7 ~~particularly~~ at predetermined times during which the disabling of the working element 100 is undesirable.

For example, the operator must be able to insert and process a workpiece 2 embodied as a bending part between the upper tool 3 and lower tool 4 of a folding press 1 without the folding press 1 being unnecessarily shut down  
5 by the protective device.

In an advantageous embodiment of the invention, therefore, in a learning process prior to the startup of the folding press 1, the camera 5 records the individual steps for machining a workpiece 2, thereby recording and  
10 storing reference images for individual machining phases. The reference images specifically depict the workpiece 2 in different machining positions.

In the operating phase of the working element 100 that follows the learning phase, the camera 5 again records the  
15 same machining steps. A comparison of the recorded images to the respective reference images can reveal the intrusion of endangered objects, such as a person's hands or fingers. The respective protection zones 7 and/or warning zones 8 can be selected to change over time for the individual  
20 machining steps.

A particular advantage of this is that the comparison to the respective reference images permits the distinction of endangered objects from the workpiece 2, which

represents a non-endangered object 55. Consequently, the  
workpiece 2 located inside the protection zone 7 does not  
cause the protective device to unnecessarily disable the  
folding press 1. A suitable, time-dependent dimensioning  
5 of the protection zones 7 and/or warning zones 8 allows the  
detection region to be flexibly adapted to the changing  
marginal conditions.

This method can encompass the following steps, for  
example:

10 In the learning phase prior to startup, a machining  
process is performed in its entirety with a workpiece 2 in  
the folding press 1.

First, the operator inserts the workpiece 2 into the  
folding press 1, so it lies inside the press 1. A  
15 retaining device may be utilized for this purpose. Because  
the upper tool 3 and the lower tool 4 are deactivated in  
this phase, the protection zone 7 is dimensioned such that  
the operator can reach into the region between the upper  
tool 3 and the lower tool 4. Particularly in this case,  
20 the protection zone 7 can also be bridged and completely  
deactivated.

Afterward, the operator removes his hands from the  
workpiece 2 and the fold line between the upper tool 3 and

the lower tool 4, so a predetermined safety distance is exceeded. During this machining step, the protection zone 7 is dimensioned in the evaluation unit 53 to encompass the region of the upper tool 3 and the lower tool 4 up to this safety distance.

A foot switch initiates the lowering of the upper tool 3 toward the lower tool 4 until the workpiece 2 is held without play between the upper tool 3 and the lower tool 4. Thus, the operator can no longer insert his hands or fingers between the upper tool 3 and the lower tool 4, so the folding press 1 no longer poses a threat to him.

The operator can therefore safely orient the workpiece 2 manually on the folding press 1. As soon as the workpiece 2 is oriented correctly on the folding press 1, ~~it~~ its image is recorded along with the upper tool 3 and the lower tool 4 as a first reference image, and stored in the evaluation unit 53.

The bending process, in which the workpiece 2 is bent upward, is then initiated. The free end of the workpiece 2 is bent upward to an intermediate position. The bending process is only performed until a sufficient spacing is present between the free end of the workpiece 2 and the

upper tool 3 to prevent the risk of injury to the operator due to a so-called upper jaw clamp.

In this position, a second reference is recorded and stored; this image depicts the positions of the upper tool  
5 3 and the workpiece 2.

During these processes, the operator is at no risk for injury, so the protection zone 7 can be selected to be correspondingly small.

Finally, the bending process of the workpiece 2 is  
10 completed, at which point the operator must remove his hands from the region of the workpiece 2, because the risk of injury is present again. A larger protection zone 7, which is adapted to the safety distance that must be maintained, is advantageously specified in this phase.

15 After the learning process has ended, the folding press 1 is enabled, with the workpiece 2 being machined in the same machining sequence that was learned in the learning process.

The operator first inserts the workpiece 2 between the  
20 upper tool 3 and the lower tool 4, which are deactivated at this time. The protection zone 7 is dimensioned such that this action does not lead to the disabling of the folding press 1.

In the next machining step, the foot switch effects the lowering of the upper tool 3 until the workpiece is held without play between the upper tool 3 and the lower tool 4. In this phase, the protection zone 7 is  
5 dimensioned such that an intrusion into the region of the fold line results in the disabling of the folding press 1.

The operator can then safely orient the workpiece 2 located between the upper tool 3 and the lower tool 4; the present embodiment of the protection zone 7 prevents the  
10 disabling of the folding press 1 due to the manual access to the workpiece 2-again.

As soon as the workpiece 2 is oriented, the bending process is initiated. The bending process is only started if the images currently being recorded in the camera 5  
15 match the first reference image showing the oriented workpiece 2.

During the subsequent bending of the workpiece 2 to the intermediate position, the operator can again manually guide the workpiece 2.

20 The current images of the camera 5 are compared to the second reference image to ascertain whether the intermediate position has been reached.

While the bending process continues from the intermediate position, operator intrusion into the region of the workpiece 2 again leads to the shutdown of the folding press 1.

5        To check the function of the protective device of the invention, a self-test is performed at predetermined intervals. The self-test is advantageously performed periodically and automatically, that is, without external activation.

10       In the present embodiment, both a static self-test and a dynamic self-test are performed.

      The static self-test essentially checks whether predetermined fixed points are present in the images generated by the camera 5. If the fixed points are absent,  
15 or have changed, an error message is generated and the working element 100 is disabled.

      This static self-test utilizes the fact that the camera 5 remains oriented precisely in terms of position on the holding device, so certain objects, such as parts of  
20 the working element 100 or other equipment, building walls or the like, remain unchanged in the detection region 6 detected by the camera 5. During a learning process prior to the startup of the protective device, such objects are

learned as fixed points and stored in the evaluation unit  
53.

This static self-test is particularly used to check  
the functioning capability of the optical components of a  
5 camera 5.

In the dynamic self-test, a defined, preferably  
endangered, test object 64 is brought into the region of a  
protection zone 7 at predetermined times. If this test  
object 64 is not recognized at the predetermined times, the  
10 working element 100 is not enabled, or if it is operating,  
it is disabled.

This dynamic self-test is advantageously performed  
before the protective device is started up. In principle,  
the dynamic self-test can also be performed during the  
15 operation of the protective device. In this case, however,  
it must be ensured that the location of entry of the test  
object 64, or its embodiment, distinguishes it from the  
endangered objects to be detected during the operation of  
the protective device. Afterward, the test object 64 is  
20 verified independently of the detection of endangered  
objects, and therefore does not impair the verification  
reliability of the protective device.



Figures 4 and 5 illustrate embodiments in which a printing press 9 constitutes the working element 100 monitored by the protective device of the invention.

Figure 4 shows a printing press 9 having a feeder 10 and an output. The feeder 10 forms the insertion region, in which paper sheets are drawn from paper stacks 11 and fed into the printing apparatus of the printing press 9. A chain conveyor 12 supplies the individual paper stacks 11, on pallets, to the feeder 10. In the region of the feeder 10, the paper stacks 11 are transported on a roller conveyor 13. After the paper sheets have been printed, a second chain conveyor 14 in the output region transports them away from the printing press 9 in paper stacks 11 stacked on pallets. In the regions of the chain conveyors 12, 14 and the feeder 10, the traveling movements of the pallets with the paper stacks 11 represent a risk of injury for the operator.

In known printing presses 9, these detection regions 6 are secured by an enclosure that completely prevents operator access. ~~This~~ However, this severely and unnecessarily limits the visibility and accessibility of the printing press 9, ~~however~~. In particular, it is

impossible or very difficult to position non-endangered objects in the detection region 6.

In the embodiment illustrated in Figure 4, a camera 5 is mounted above the printing press 9 such that the  
5 detection region 6 detected by the camera encompasses the regions of the feeder 10 and the chain conveyors 12, 14.

Monitoring with the camera 5 is performed analogously to the embodiments of Figures 1 through 3. In particular, the detection region 6 is again divided appropriately into  
10 protection zones 7 and possibly warning zones 8, inside which endangered objects can be detected.

Figure 5 shows a second embodiment of a protective device in a printing press 9. The printing press 9 corresponds to the printing press 9 according to Figure 4.  
15 In contrast to the protective device according to Figure 4, however, the protective device according to Figure 5 has two cameras 5. The detection region 6 detected by the first camera 5 encompasses the first chain conveyor 12 for supplying paper stacks 11 to the printing press 9.

20 The detection region 6 detected by the second camera 5 encompasses the second chain conveyor 14 for transporting paper stacks 11 away from the printing press 9.

The detection regions 6 recorded by the cameras 5 are dimensioned such that their widths are larger than the widths of the chain conveyors 12, 14. In this way, endangered objects can be detected before they have entered the region of the chain conveyors 12, 14. For orienting the operator, the borders of the protection zones 7 inside the detection regions 6 can be marked with lines on the floor of the room housing the printing press 9.

In the embodiments according to Figures 4 and 5, the paper stacks 11 transported on pallets are learned as non-endangered objects and stored in the evaluation unit 53 before the protective device is started up.

Figure 6 illustrates a feeder 10 of a printing press 9 that is monitored by a protective device having a camera 5. The embodiment of the printing press 9 corresponds to that of the printing press 9 according to Figures 4 and 5.

The feeder 10 essentially comprises a frame 15, inside which a paper stack 11 is disposed. A gripping element 16 draws paper sheets from the top of the paper stack 11 into the printing apparatus, not shown, of the printing press 9.

The camera 5 is mounted above the feeder 10 such that the detection region 6 detected by the camera 5 encompasses the top of the paper stack 11 and the gripping element 16.

The protection zone 7 inside the detection region 6 is dimensioned to completely encompass the working region of the gripping element 16, which executes movements that could injure the operator.

5        Figure 7 shows an embodiment of a protective device that serves to monitor the region in front of a working element 100 embodied as a working robot. In the present embodiment, a welding robot 17 constitutes the working robot.

10        The welding robot 17 is located in an enclosed production cell 18 having an enclosure 19, which is provided with an access opening 20. Objects are introduced into and transported out of the production cell 18 via the access opening 20. In addition, the operator has access to  
15 the production cell 18 via the access opening 20. The region of the access opening 20 constitutes the detection region 6 ~~detected~~ monitored by the camera 5 of the protective device.

20        The detection region 6, which is again divided into one or more protection zones 7 and possibly warning zones 8, is located at a distance from the working region of the welding robot 17. Consequently, if an endangered object enters a protection zone 7, the welding robot 17 is

promptly disabled before the endangered object can pass through the protection zone 7 to the welding robot 17. In this case, persons constitute the endangered objects. Non-endangered objects, such as the workpieces 2, that can  
5 enter a protection zone 7 are preferably learned and stored in the evaluation unit 53 prior to the startup of the protective device.

The invention has been described in detail with respect to preferred embodiments, and it will now be apparent from  
10 the foregoing to those skilled in the art, that changes and modifications may be made without departing from the invention in its broader aspects, and the invention, therefore, as defined in the appended claims, is intended to cover all such changes and modifications that fall within the  
15 true spirit of the invention.

## ~~LIST OF REFERENCE CHARACTERS~~

- ~~(1) Folding press~~
- ~~(2) Workpiece~~
- ~~(3) Upper tool~~
- ~~(4) Lower tool~~
- ~~(5) Camera~~
- ~~(6) Detection region~~
- ~~(7) Protection zone~~
- ~~(8) Warning zone~~
- ~~(9) Printing press~~
- ~~(10) Feeder~~
- ~~(11) Paper stack~~
- ~~(12) Chain conveyor~~
- ~~(13) Roller conveyor~~
- ~~(14) Chain conveyor~~
- ~~(15) Frame~~
- ~~(16) Gripping element~~
- ~~(17) Welding robot~~
- ~~(18) Production cell~~
- ~~(19) Enclosure~~
- ~~(20) Access opening~~

## ABSTRACT

The invention relates to an apparatus and a method for monitoring a detection region ~~(6)~~ of a working element (100). The apparatus has at least one camera ~~(5)~~ for continuously ~~detecting~~ monitoring the detection region ~~(6)~~, and an evaluation unit (53), into which image information generated by the camera ~~(5)~~ is read. In the evaluation unit (53), a comparison of the image information to reference images, and/or a color-feature analysis, allow(s) the detection of endangered objects within at least one protection zone ~~(7)~~ in the detection region ~~(6)~~. If at least one endangered object is detected inside the protection zone ~~(7)~~, the evaluation unit (53) disables the working element (100). In contrast, if no endangered object (54) is located inside the protection zone ~~(7)~~, the evaluation unit (53) enables the working element (100).

~~Figure 1~~

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